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THE SOIL IN RELATION TO ITS PARENT MATERIAL AND ENVIRONMENT

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THE SOIL IN RELATION TO ITS PARENT MATERIAL AND ENVIRONMENT

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FOREWORD

One of the policies of the Soils Section is to assist other technicians attain a greater knowledge of the more practicable fundamentals of soil science and practice. Such a policy has been established with the thought that inter-technique education is one of the steps necessary for the attainment of a truly coordinated conservation program. It is hoped that other technical sections will agree to such a policy and reciprocate by assisting Soils technicians in a similar manner.

It is further believed by the personnel of the Soils Section that one of the various promising methods of mutual assistance in this respect is the preparation, by each section, of educational technical bulletins for the special benefit of the other technical sections with whom they must cooperate. This is the first of a series of such bulletins planned by the Soils Section. Further efforts in this direction will be determined largely by the reaction of other technicians to the first few bulletins issued in this proposed series. Frank comments, suggestions, and constructive criticism will be appreciated from both soils and non-soils technicians. The desire is to make these bulletins fulfill the need. The number, character, sequence, etc. of the bulletins can be varied as needed and desired.

The present plan is to cover, in a brief and practical manner, at least the subjects outlined below, giving particular attention to those matters which are significant from the standpoint of the soil and moisture conservation program of Region 8. This first bulletin must of necessity be somewhat general in character, as its purpose is to present a background for the proper understanding of subjects to be covered later in the series.

1. The soil in relation to its parent material and environment.
2. The physical properties of soils.
3. The chemical properties of soils.

4. The composition of soils.
5. The elements of soil classification and mapping.
6. Moisture considerations.
7. Fertility considerations.
8. Erosion and erodibility.
9. Soil-plant relationships.
10. Soil considerations and land use.
11. Soil considerations relative to structures and land treatment.
12. Soil considerations relative to the work of particular techniques cooperating with the Soils Section, i.e., Range Management, Engineering, Agronomy, Woodland Management, Wildlife Management, etc.

The above outline represents the present plan of approach. It may, and likely will be, revised, particularly if requests are presented for the treatment of subjects not listed.

THE SOIL IN RELATION TO ITS PARENT MATERIAL AND ENVIRONMENT

Soils don't just happen. In a sense, they are "born" of certain surface geological deposits, which, in soils parlance, are termed "parent materials". Furthermore, they take a certain course of development, going through rather definite stages of being and ultimately attain rather definite stages of growth or maturity. The character of the soil during its different stages of development and during its later equilibrium stage of maturity is determined largely by two factors, (1) its original parent material and (2) the environment which prevails during its development. Once the student of soils realizes this essential relationship, he has opened the proper mental path toward the simplest and most logical explanation and understanding of soils wherever he may have occasion to examine them.

Soil, therefore, is not just "dirt", but a definite natural body with characteristics as definite as those which occur in plants, stars, geological formations, etc. However, the generalities above given merely state the general situation. They do not give sufficient information for a practical understanding of specific soils as one may see them in the field. Further explanation is attempted below.

The Parent Materials of Soils

Most of us can differentiate shales, sandstones, conglomerates, river deposits, lake deposits, lava deposits, etc. from each other. Generally speaking, these represent broad types of parent materials of soils. Also, generally speaking, the parent material of a soil is the underlying deposit over which, and from which, the soil has developed. The deposits may be solid rock or unconsolidated sands, clays, etc.

In other words, after deposition and exposure to the elements, these "raw" deposits are slowly acted upon by the various elements of natural environment, i.e., if not removed too rapidly by natural erosion, as on the steeper erosive slopes, or when too subject to wind erosion, under conditions of insufficient vegetative protection. The elements of environment-temperature changes, moisture, chemicals in solution, oxygen from the air, bacteria, plants, and decomposing plant residues, etc. physically and chemically simplify these original raw geological materials, and soil formation gets under way. More will be said of the formative environmental complex later. It is intended at this point to give attention primarily to parent materials.

Over the territory occupied by Region 8 a great variety of parent materials exist. They differ greatly in their original sand, silt, clay, and chemical content, in their hardness, and in their ability to decompose or disintegrate under the influence of the various modifying factors of the environment. In other words, in that great natural laboratory, the earth's surface, an almost infinite variety of earth materials, i.e., soil "parent materials", may be found. Consequently, even if the environment were uniform over the

region, one would expect a great variety of soils.

From a practical point of view, however, the question immediately arises: "What relationships can be pointed out between parent materials and soils that are of value from a practical soils viewpoint in Region 8?"

Even when the field is restricted to this one question it becomes entirely too broad a question to answer adequately in a brief bulletin. However, the remainder of the discussion of parent materials is limited to a discussion of the practical relationships above-mentioned.

In general, coarse-grained materials - sandstones, conglomerates, sandy river and fan wash, etc. - result in coarse-textured or "light" soils. Likewise fine-grained materials - shales and clay deposits of various kinds - usually result in fine-textured, or "heavy" soils. Likewise, also, rocks of certain chemical composition usually result in moderately heavy to heavy-textured soils, e.g., basaltic lavas and limestones. However, many exceptions to the above generalizations occur, particularly in areas of higher rainfall, due largely to the intense influence of environment on the original parent materials. In general, the influence of the parent material on the soil which develops increases as the rainfall decreases.

The amount of alkali and lime in soil is also largely determined by the quantity of these compounds in the original parent material, or in the end products of their natural simplification. For example, limestones and other high-lime rocks usually leave considerable lime in the surface or subsoils. Likewise, parent materials high in alkali, such as the Mancos Shales, leave considerable alkali salts in the soil, unless the amount of moisture that has percolated deeply through the soil has been high. The most common location for alkali is, of course, the bottom or natural flood area lands. This is largely the result of waters carrying chemical end products from higher ground to the flood areas and gradually increasing the quantity through such concentration over a long period of time. In this instance the parent materials become charged with salts from outside sources.

Some parent materials develop into soils very slowly, others relatively rapidly, geologically speaking, but the process is slow, at best. Under some situations, the development is so slow, as compared to removal by natural erosion, that soils always remain shallow and never reach maturity, especially under a combination of slow development and erosive slopes, or small density of protective vegetative cover.

Many other practical influences of parent materials on soils could be pointed out. However, probably sufficient has been stated to emphasize the close relationship of one to the other, i.e., a genetic or parent relationship of the raw deposits to the developing soils.

The Natural Environment and Soil Development

In a previous paragraph soil development has been likened to a chemical reation in which the parent materials represented the original chemicals selected for the reaction. To complete this simile, the various elements of natural environment represent the conditions which influence the reaction and the final end products which result. In the laboratory one can vary a reaction, either by changing the original chemicals or some condition of the reaction. Nature likewise influences soil development. Wherever one finds a change in the natural surface geological deposit, or in one or more of the conditions of the environment - precipitation, temperature conditions, type of plant cover, water table condition, etc., - one naturally looks for a change in soil.

We all recognize that environment changes both broadly and locally, i.e., zonally and intra-zonally. For example, in going to higher elevations in this region, we usually look for cooler temperatures, higher precipitation, and changes from grass or shrub vegetation to woodland or forest. At the same time, although we sometimes don't adequately appreciate the fact, there are significant local changes in environment within a given general environment zone. Such local differences are associated mostly with differences in slope and exposure and conditions relative to concentration of moisture. For example, within a grassland zone, with its usual associated conditions of moisture, temperature, etc., we may find woodland or sedge in local bottoms and certain browse plants on the sunnier, drier exposures, with associated differences in soil moisture, water table, natural erodibility, depth of soil, and other factors. In other words, environmental changes, although broad and zonal, are also local or intra-zonal, and sometimes local differences are greater in contrast than those of adjoining broad zones.

Corresponding differences may also usually be expected in soils, such differences occurring with differences in penetrating moisture, water table, natural erodibility, type and density of cover, temperature variations, etc., which in turn occur with differences in slope, exposure, and conditions for concentration of moisture and salts. Explanations for the soil variation accompanying the environmental variations, both local and zonal, will be attempted in the discussion of the soil development process given below. The influence of the various elements of environment on the character of the soil which is developed is so well marked and characteristic that terms such as forest soils, semi-arid soils, grassland soils, prairie soils, etc. are used to broadly group them on the basis of such relationship.

The Soil Development Process

As explained above, a given soil and the particular qualities which characterize it are the resultants of a particular environmental complex acting on a particular parent material, or earth deposit. In succeeding paragraphs the attempt is made to explain briefly and in simple terms the essential phases of and factors involved in the soil development process, according to the generally accepted theory of modern soil science.

In the first place, there is the well-known natural process of physical and chemical simplification of rock or rock materials, resulting in the production of a mass of smaller particles from original solid masses or bodies. It

also results in the production of end products of simpler composition, varying in solubility from insoluble to very soluble. Temperature changes, solution, carbonation, hydration, oxidation, the action of bacteria and other micro-organisms, plant and animal activity, etc. all enter into the decomposing or simplifying process.

Concurrently with the refining in size of particles and the production of simple end products, water from repeated precipitation repeatedly percolates through the soil and carries soluble products and fine particles downward. Highly soluble salts; the less soluble salts, such as lime carbonate and gypsum; and colloidal organic and mineral particles gradually move downward and are deposited or precipitated out in lower portions of the soil. The positions in which they deposit depend largely upon the average depth of penetration of moisture under the prevailing rainfall and certain inherent chemical and physical conditions in the soil.

With repeated downward transfers of soluble compounds and fine particles and their subsequent deposition at different levels in the lower soil, one can readily appreciate the common chemical and physical differences between the soil occurring at various depths.

So marked are such differences at various depths in most soils that the term "profile" is used to indicate the more or less layered arrangement which develops. As the result of the extraction of material from the upper portions of the soil and re-deposition below, the soil tends to become a series of blankets of different kinds of soil superimposed one over the other, rather than a uniform product. The term "soil profile" merely refers to the usually cross section of this series of soil layers for a given kind of soil.

In general, the tendency is for the upper part of the soil to be sandier in texture, the result of the sandy residue remaining after the finer and stickier particles are removed and deposited below to make a heavier subsoil.

The subsoil is usually also harder and more compact, probably the effects of deposition of cementing compounds and of pressure. It is also usually more alkaline in reaction and higher in lime content, as one would expect.

Organic matter is usually greater in content in the surface, as the result of accumulation of plant residues.

Other differences between the various layers or "horizons" of soils will be discussed under proper headings in later bulletins. The important point intended to be stressed here is that soils develop because environmental factors work on parent material to simplify it, to add organic matter to it, and to move certain products downward and re-deposit them. These and various other natural processes are the growth processes of the soil.

From what has been pointed out above, one can readily appreciate that each soil has a more or less definite line of development, predetermined by its parent material and existing environment. In the light of this relationship, one can better understand why soils men speak of "young" soils, "poorly developed" soils, "mature" soils, etc. They are simply referring to the particular

stage of development in comparison to the mature or equilibrium stage at which the soil ultimately arrives. This is important largely in that it reflects certain characteristics which go with these relative stages of development. For example, heavy subsoils frequently occur in the more mature soils and lime and salts go deeper as the soils increase in age.

One can also better appreciate why, in studying soils of an area and mapping them, the soils technician looks for the soil to change in relation to differences in parent materials, climate, vegetation, slope, exposure, water table influence, and other natural variables on the landscape. This gives him a logical basis for locating his test pits, for making his various examinations, and for estimating his soil type boundaries.

The soil-parent material-environment relationship also explains why a soils man looks to the soil to throw light on past environment and why he can frequently fairly accurately predict the type of soil which will occur in an area if he is informed of the parent material and the existing elements of the environment.

The profile or "superimposed blanket" arrangement of many soils fully illustrates the need for an examination of the subsoil as well as the surface. Even a trained soils man cannot just walk over an area and pass intelligent judgment as to the nature of the soils, unless he is so familiar with the soils of the area that he can interpret the profile from his knowledge of the relation of the various soils to surface character, slopes, plant cover, and other environmental features. To get the full benefit of soils information in planning of any sort, the soils man should have been allowed sufficient time to dig pits, to study the area adequately, to classify his soils properly, to map the boundaries of the types, and to analyze the information which he has gathered. Casual surface examinations are inadequate. The real soils story is usually written underneath the ground, and, unfortunately, human vision cannot penetrate beyond the immediate surface.

The statements in the previous paragraph illustrate the need for adequate surveys to be made well ahead of planning, if the soil factor is to be fully evaluated and fitted into plans and operations.